

MODIS/VIIRS Cal/Val Using RadCaTS

Jeffrey Czaplá-Myers and Nikolaus Anderson

Wyant College of Optical Sciences
University of Arizona

MODIS/VIIRS Calibration Workshop
1 May 2023



- The Radiometric Calibration Test Site (RadCaTS)
- Current status of RadCaTS
- Radiometric calibration and surface reflectance validation results
- Summary and future work



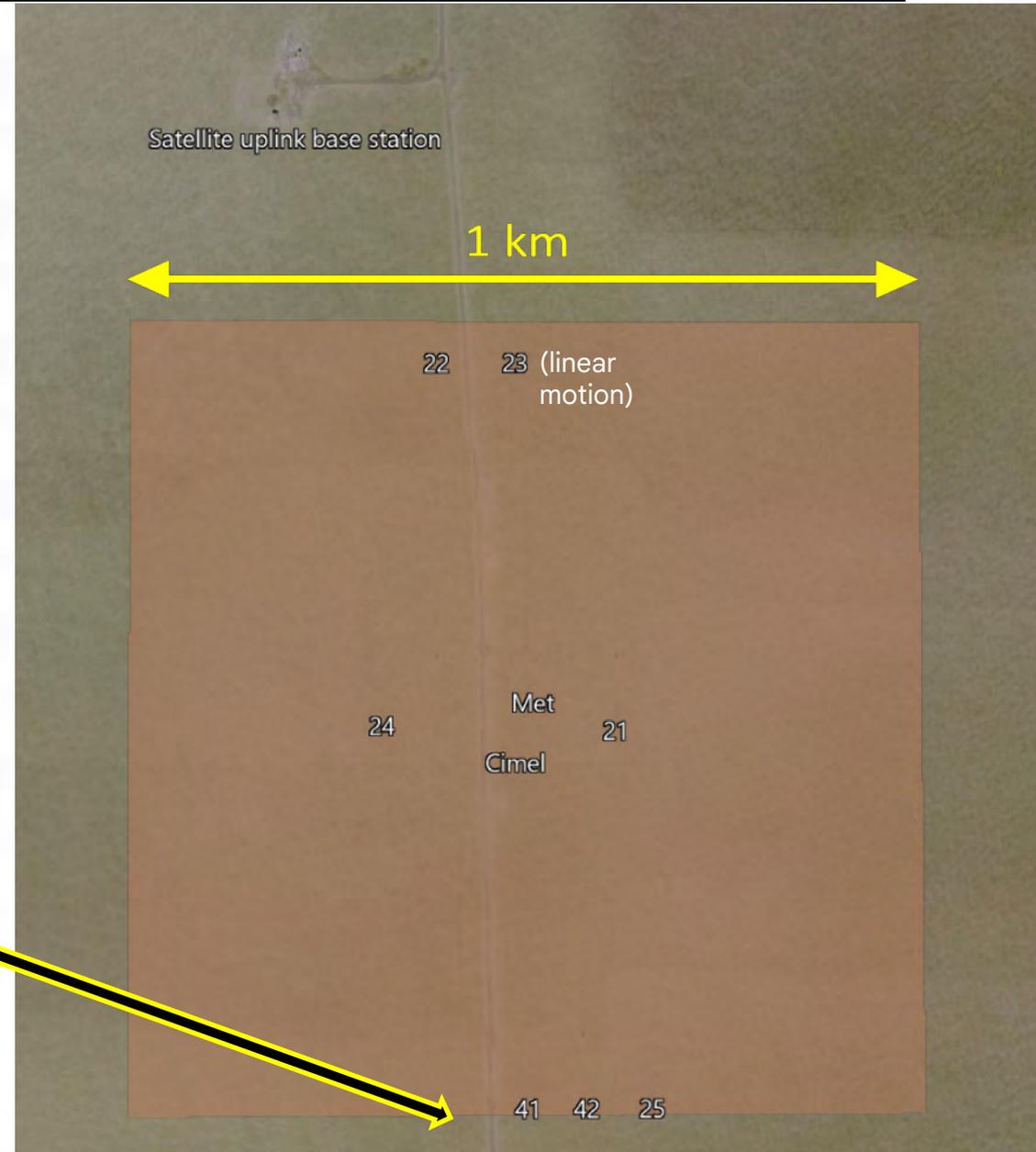
- UArizona is using the Radiometric Calibration Test Site (RadCaTS) at Railroad Valley, NV, as the primary data collection site
- RadCaTS has been in operation in its current form since 2012
- Previous studies were used to determine amount and placement of GVRs for spatial sampling similar to traditional reflectance-based approach
- Reflectance-based approach and RadCaTS are two independent methods
 - Reflectance-based:
 - Surface reflectance: ratio method of surface to reference panel
 - Automated solar radiometer used for atmospheric measurements
 - RadCaTS
 - Surface reflectance: absolutely-calibrated multispectral radiometers
 - AERONET Cimel solar/lunar photometer used for atmospheric measurements
- MODTRAN 6 currently used to determine atmospheric propagation in both cases



Equipment at RadCaTS



- 7 ground-viewing radiometers (GVRs)
 - All in nadir viewing configuration (as of 18 Oct 2020)
 - Two were previously in GOES-E and -W viewing config
 - One GVR (23) has 88 cm of linear motion
- 1 VNIR spectroradiometer (SpAM)
- 2 Cimel sun photometers (314 and 786)
- Met station
- Satellite uplink
- Web camera



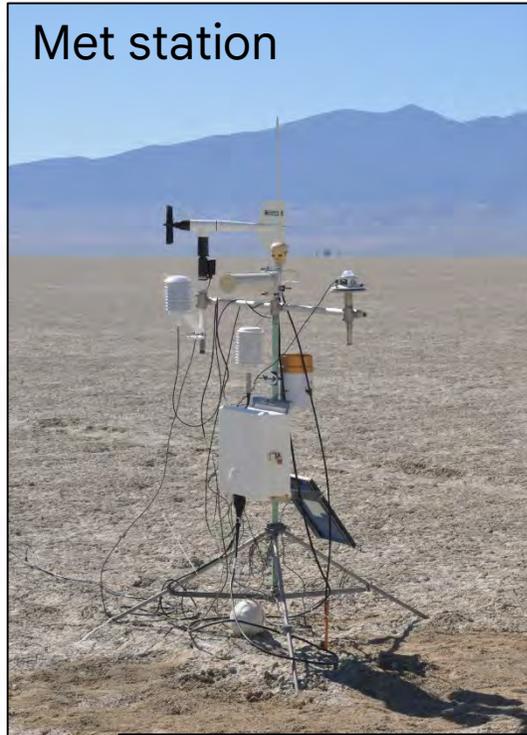


Equipment at RadCaTS

VNIR Spectrometer



Met station



Web cam



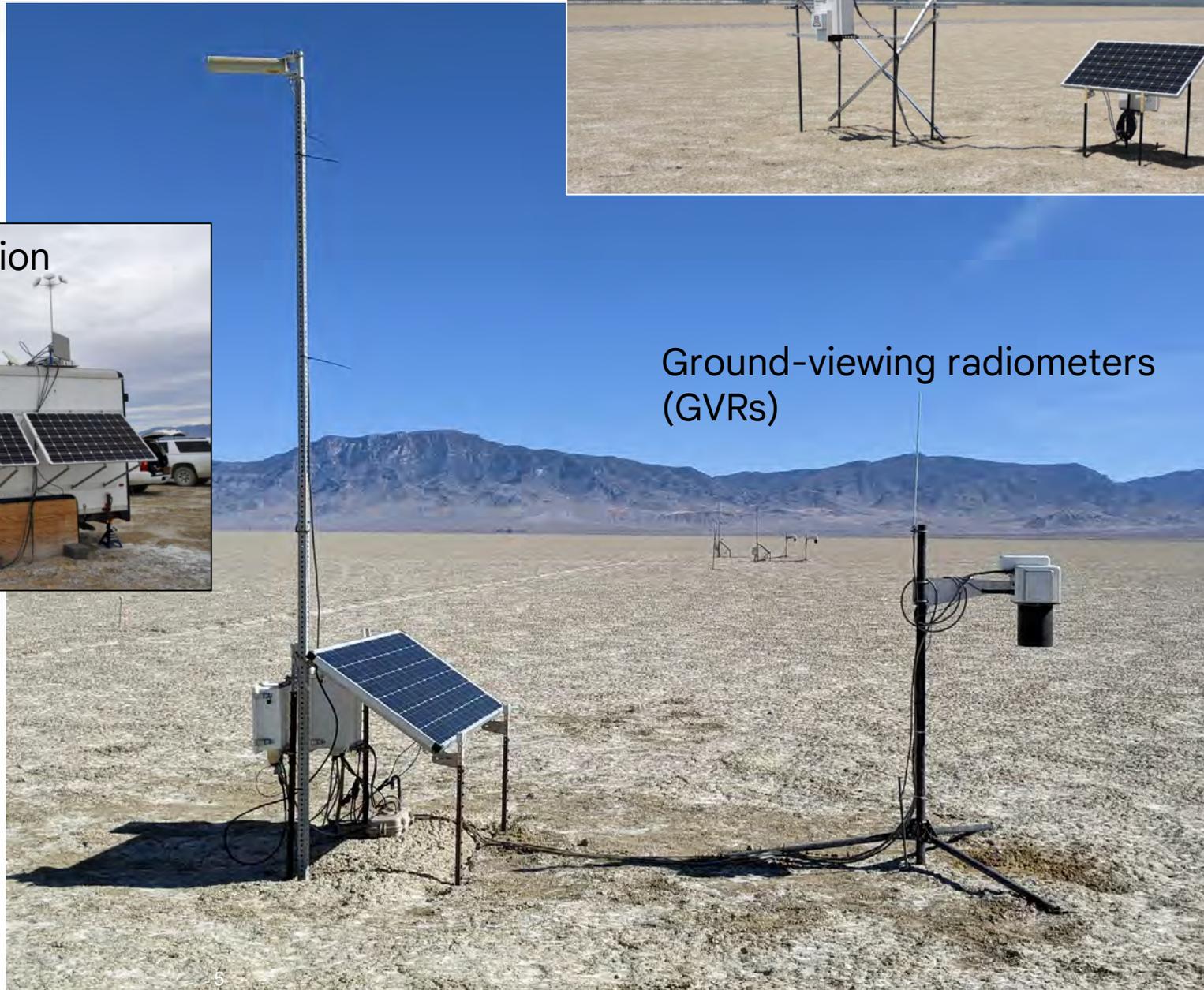
Satellite uplink station



Cimel CE318-T



Ground-viewing radiometers (GVRs)





- Operating since Mar 2020
- Same 10° field of view as current GVRs
- Mounted at same height as current GVRs
- Translation: ~ 88 cm at a rate of 0.5 cm s^{-1}
- Data collected every 10 s (equivalent to 5 cm)
- 6.8 minutes for full lap
- Operates from 16:00–23:00 UTC



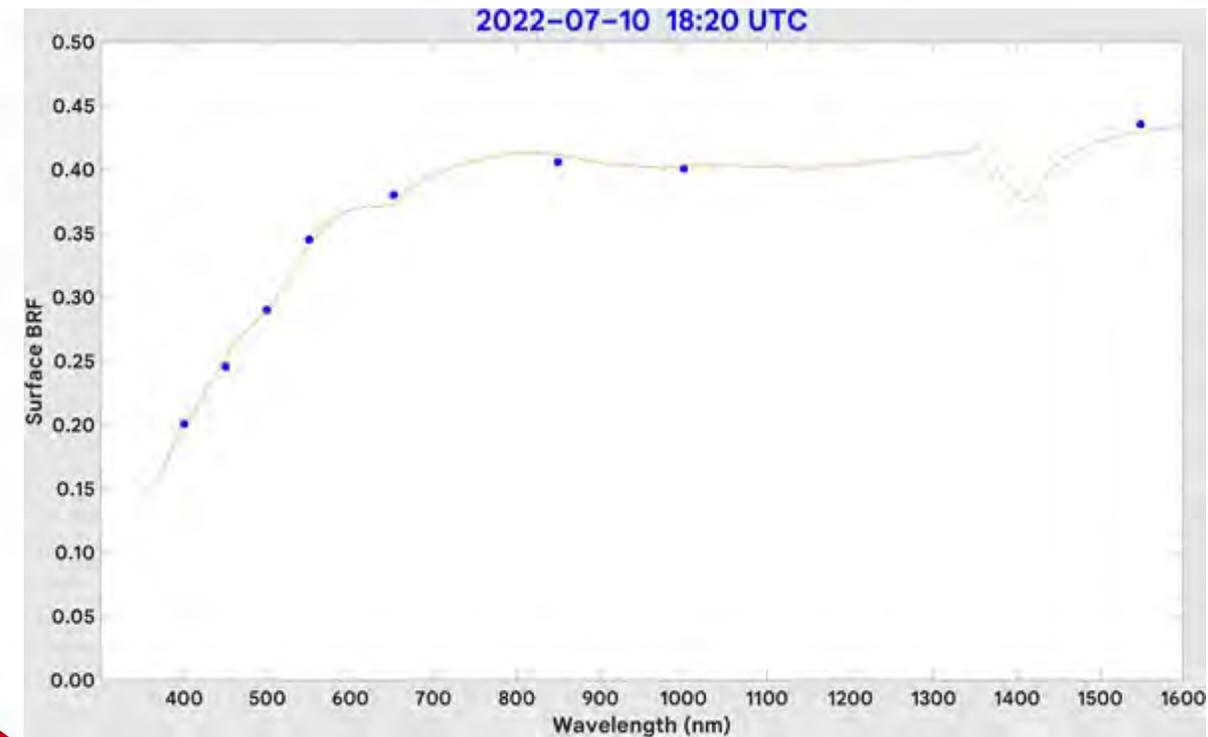
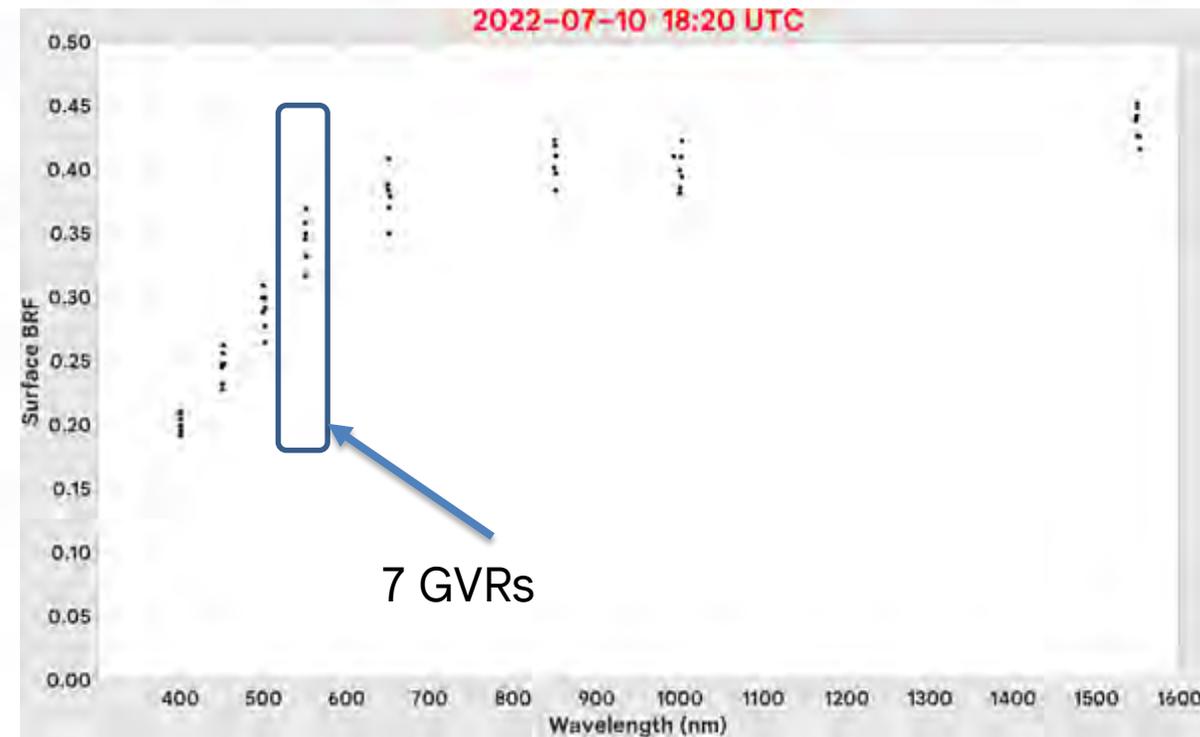


Surface Reflectance Determination at RadCaTS



- Determine surface reflectance in each of GVR's 8 spectral bands
- Determine the average for each of the 8 bands
- Convert the multispectral results to hyperspectral by fitting to library of data collected from 2000–2022 using portable spectroradiometer (e.g. ASD)

10 Jul 2022





Support Instrumentation and Measurements

- Calibration Test Site SI-Traceable Transfer Radiometer (CaTSSITTR)
- Same seven VNIR bands as RadCaTS ground-viewing radiometer
 - 400, 450, 500, 550, 650, 850, 1000 nm
- One-person operation, wireless data logging
- Temperature-controlled focal plane (35 °C)
- Travelling transfer radiometer for test site intercomparison and uncertainty analysis (e.g. RadCalNet)

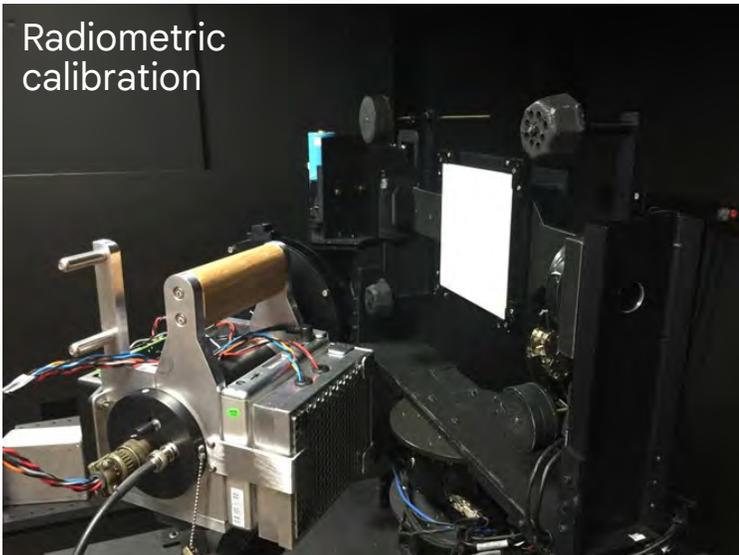
Field deployment at RadCaTS



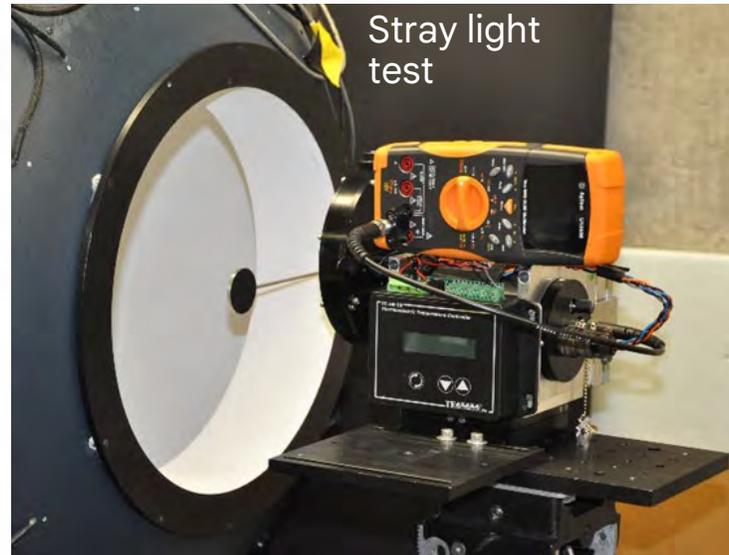
Field deployment at Pinnacles, Australia



Radiometric calibration



Stray light test

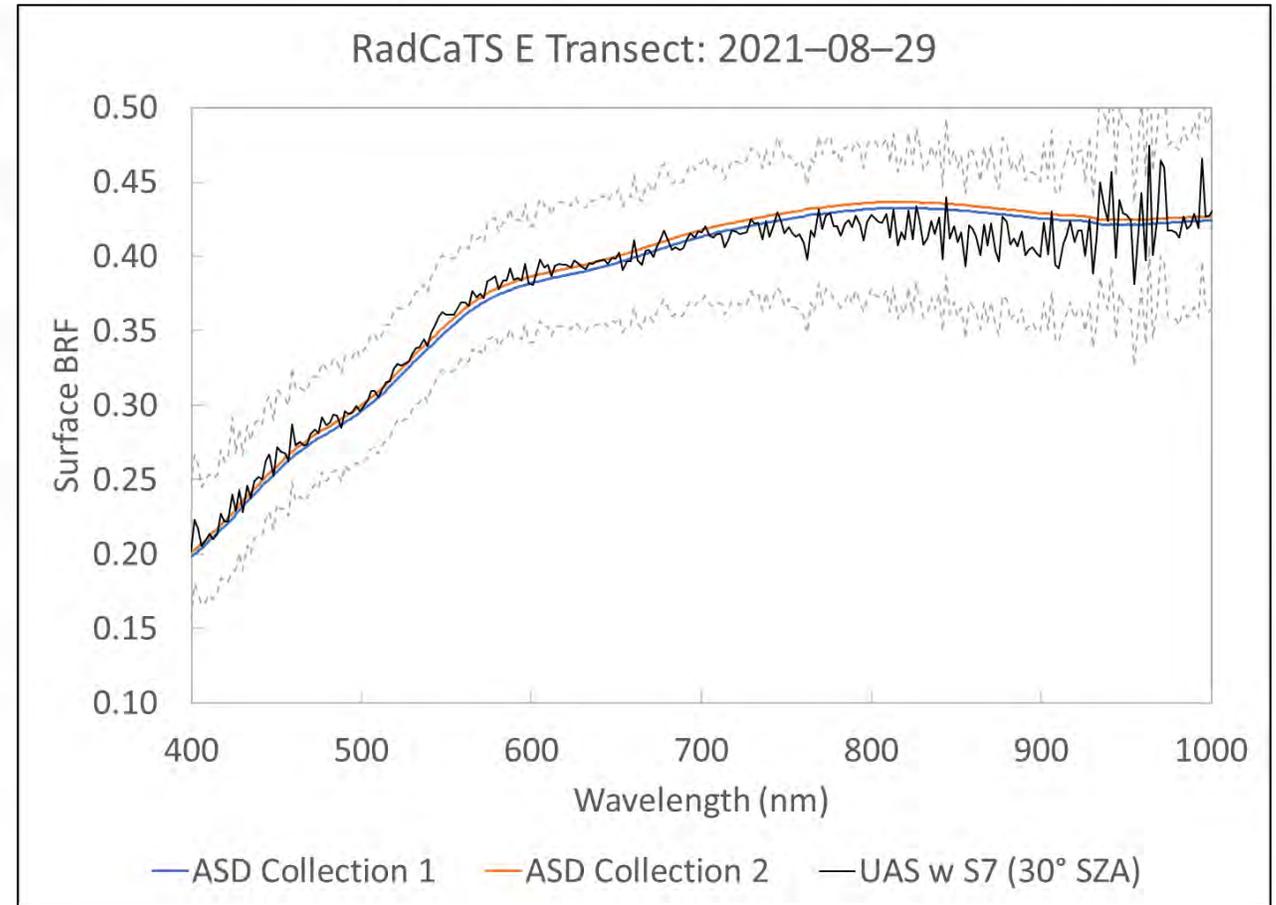
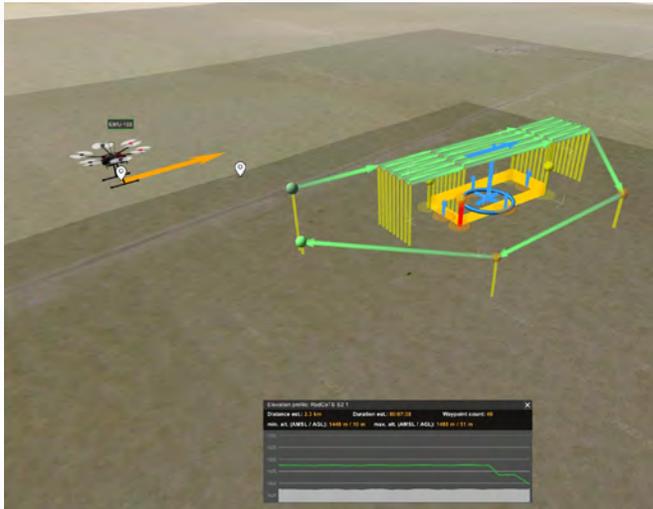




- UAS
 - Laboratory calibration of Headwall hyperspectral instrument
 - Spectral
 - Radiometric
 - Temporal stability
 - Deployment at Railroad Valley and partner sites for BRDF and spatial uniformity analysis
 - RRV field measurements and comparison to previous PARABOLA-III and ULGS-II results
 - Spatial uniformity comparison with GVR linear motion system



- Measurements of surface reflectance: Aug 2021
 - Headwall system (DJI Matric 600 Pro and Nano-Hyperspec spectrometer)
 - On-site personnel (ASD)





Flight and Sensor Testing at UArizona



- Testing of automated flight software (UgCS)
- Testing of Headwall Nano-Hyperspec spectrometer (400 nm to 1000 nm)





- Source:
 - LAADS DAAC

- Radiometric Calibration
 - Terra & Aqua MODIS: Collection 6.1 (2013–2023)
 - SNPP VIIRS: Collection 1 & 2 (Archive 5000 & 5200) (2013–2023)
 - NOAA-20 VIIRS: Collection 2.1 (Archive 5201) (2018–2023)

- Surface Reflectance Validation
 - Terra & Aqua MODIS: Collection 6.1 (2013–2023)
 - SNPP VIIRS: Collection 1 (Archive 5000) (2013–2023)
 - NOAA-20 VIIRS: No imagery



Sensor Viewing Conditions (as of 1 Jan 2021)



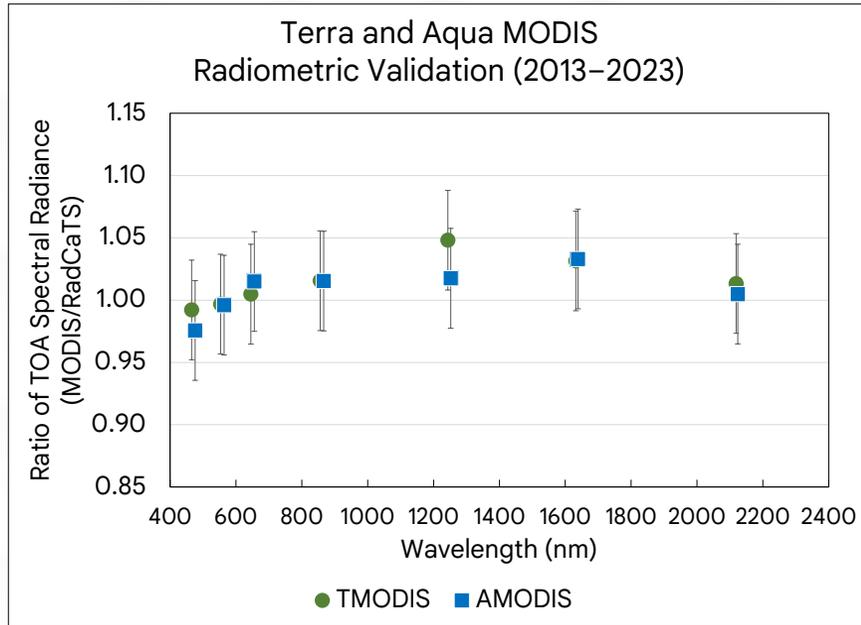
Sensor	Time (UTC)	View Zenith Angle	View Azimuth Angle (from ground)
TMODIS	18:32	13°	102°
	18:38	2°	103°
	18:44	10°	284°
AMODIS	20:48	7°	76°
	20:55	5°	257°
SNPP VIIRS	20:33	11°	75°
	20:39	1°	75°
	20:45	10°	257°
NOAA-20 VIIRS	20:33	11°	75°
	20:39	1°	75°
	20:46	10°	257°



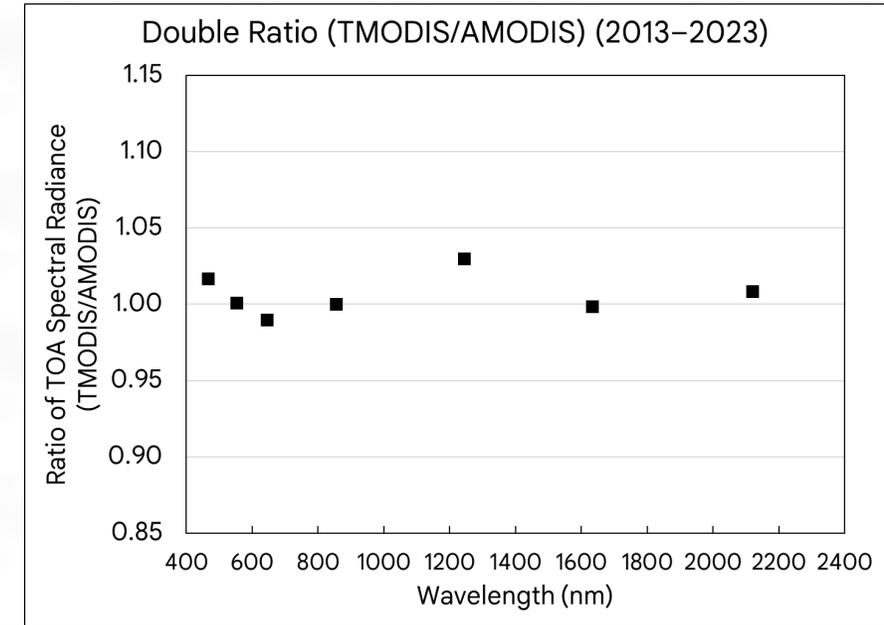
Current MODIS Radiometric Calibration Results



- 2013–2023
- **TMODIS: N=192,** **AMODIS: N=138**



Double ratio to remove RadCaTS



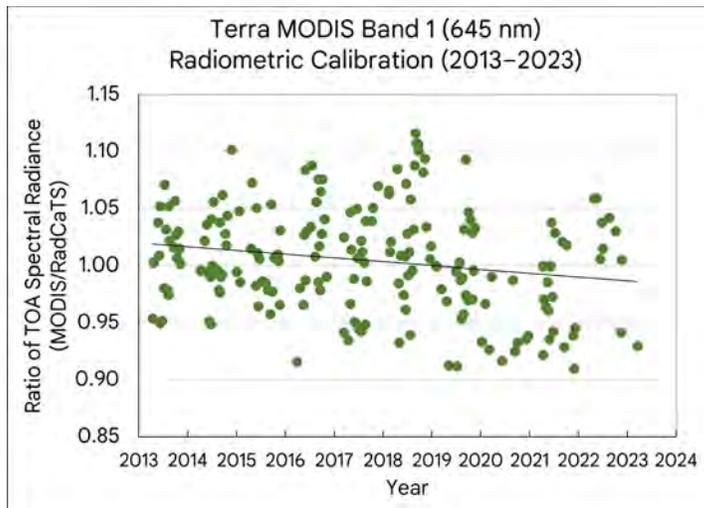
- MODIS Bands: 1–7
- Double ratio: $(\text{TMODIS}/\text{RadCaTS})/(\text{AMODIS}/\text{RadCaTS}) = \text{TMODIS}/\text{AMODIS}$



Temporal Radiometric Calibration Results

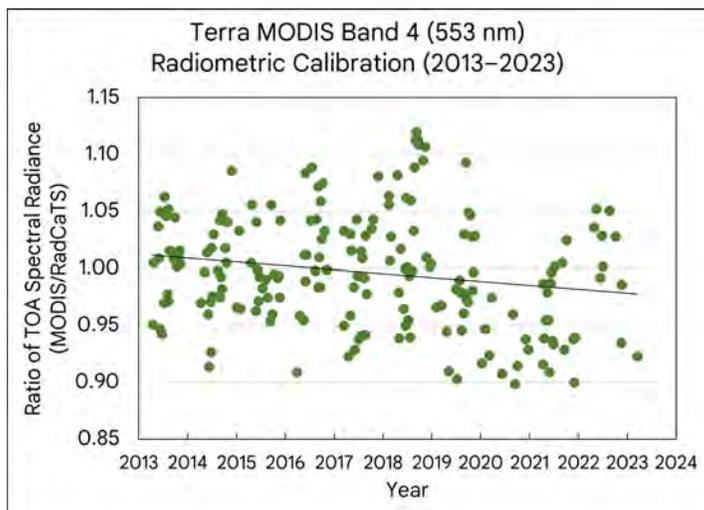
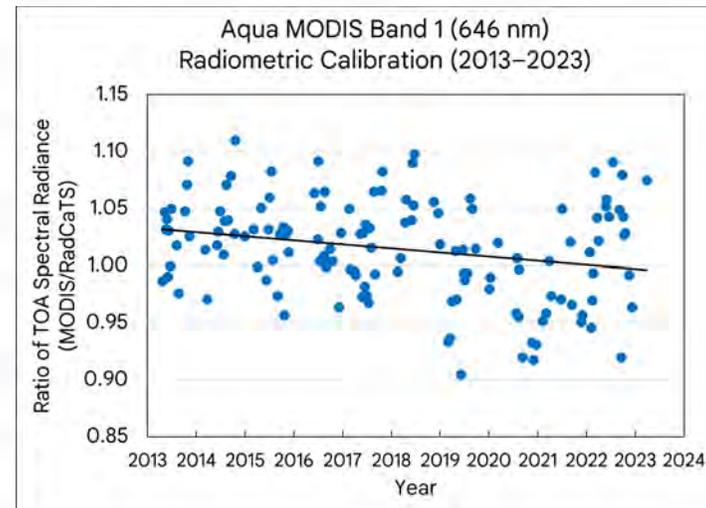


Terra MODIS

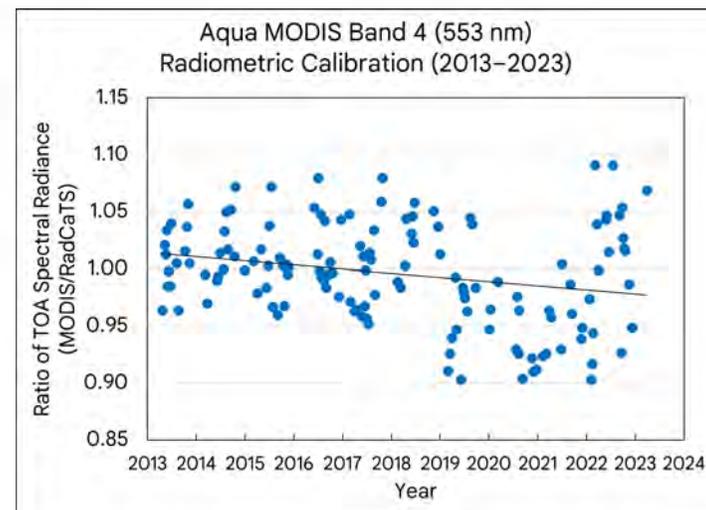


Band 1 (645 nm)

Aqua MODIS



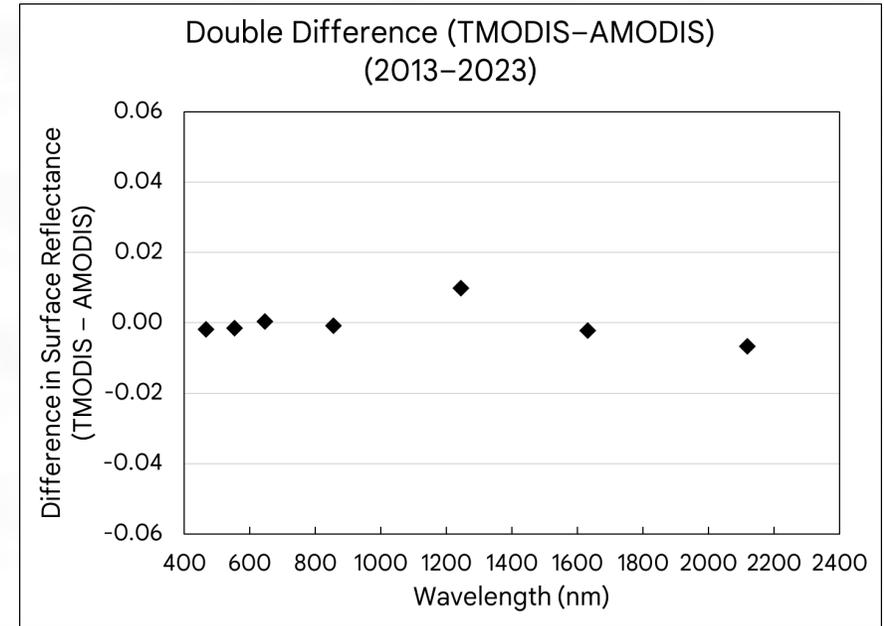
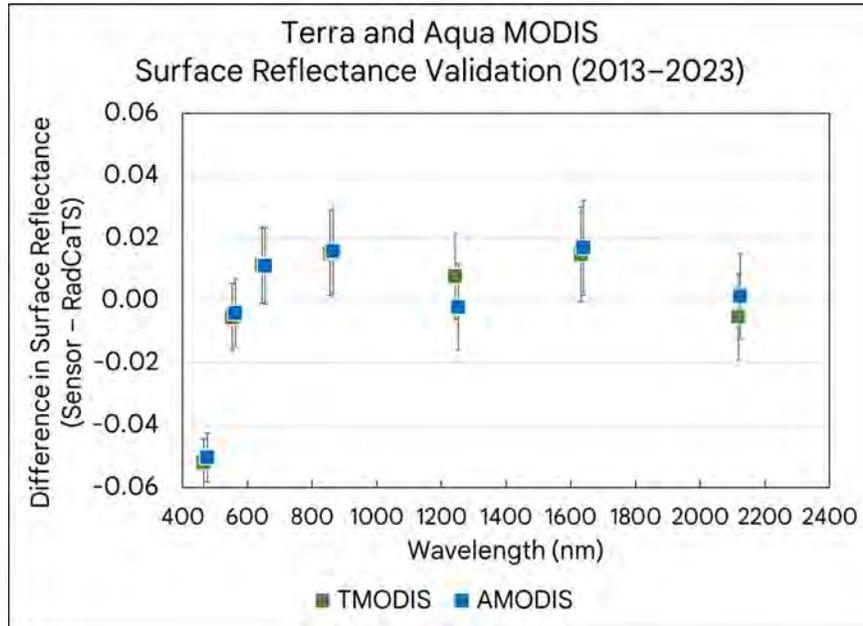
Band 4 (553 nm)



Current MODIS Surface Reflectance Validation Results

- 2013–2023
- TMODIS: N=192, AMODIS: N=138

Double difference to remove RadCaTS



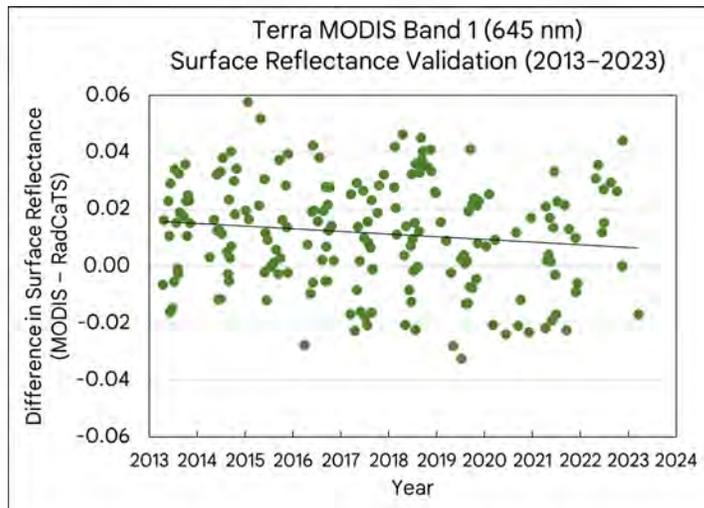
- MODIS Bands 1–7
- Double difference: $(\text{TMODIS} - \text{RadCaTS}) - (\text{AMODIS} - \text{RadCaTS}) = \text{TMODIS} - \text{AMODIS}$



Temporal Surface Reflectance Validation Results

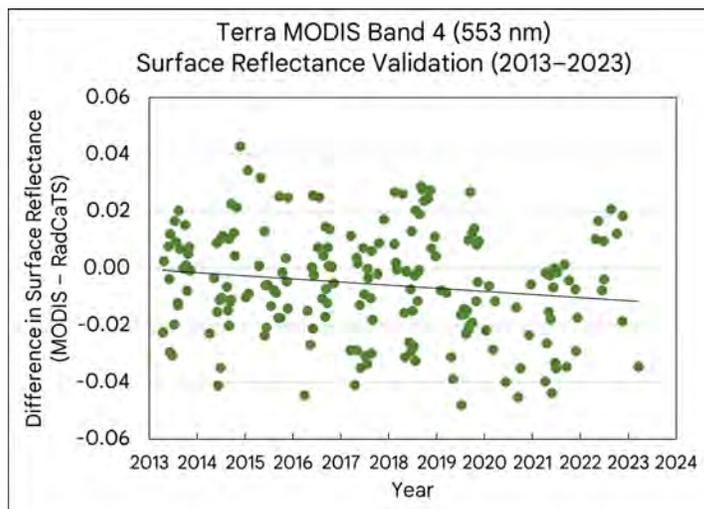
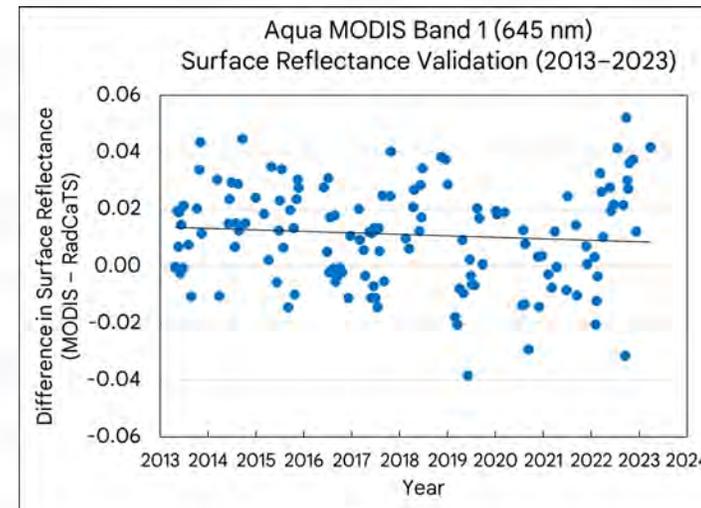


Terra MODIS

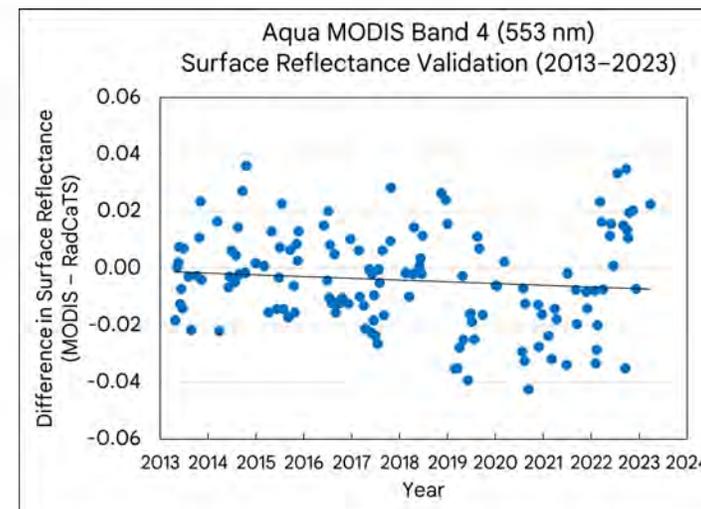


Band 1 (645 nm)

Aqua MODIS



Band 4 (553 nm)





THE UNIVERSITY OF ARIZONA

Wyant College
of Optical Sciences

VIIRS Results





Current VIIRS Radiometric Calibration Results

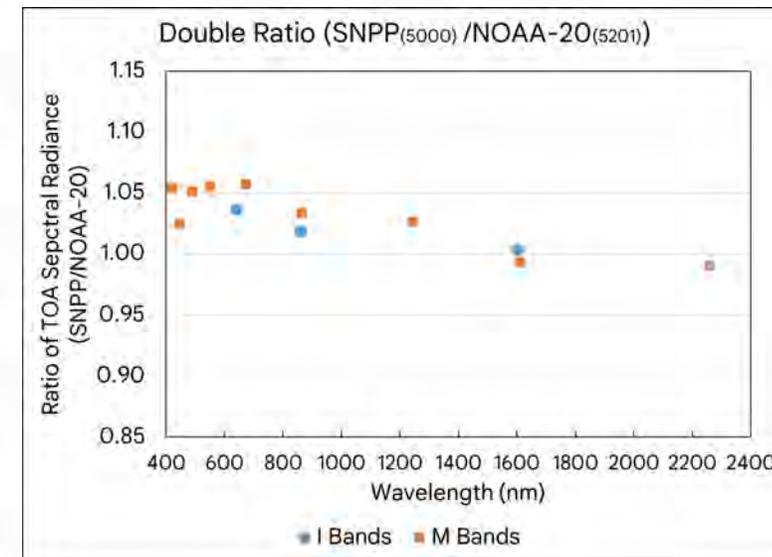
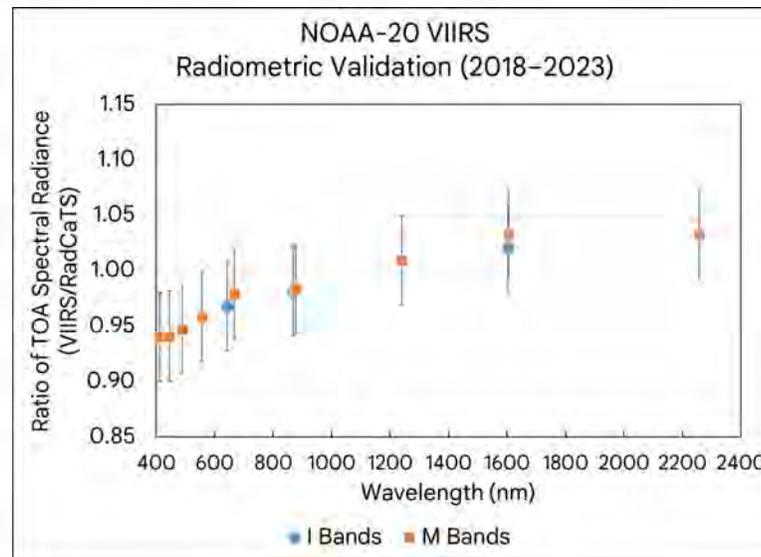
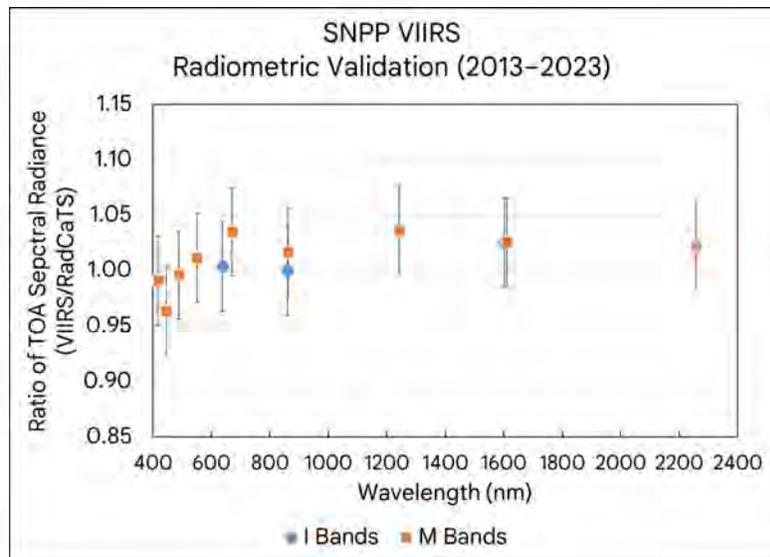


- 2013–2023 (SNPP), 2018–2023 (NOAA-20)

• SNPP: N=225

NOAA-20: N=72

Double ratio to remove RadCaTS



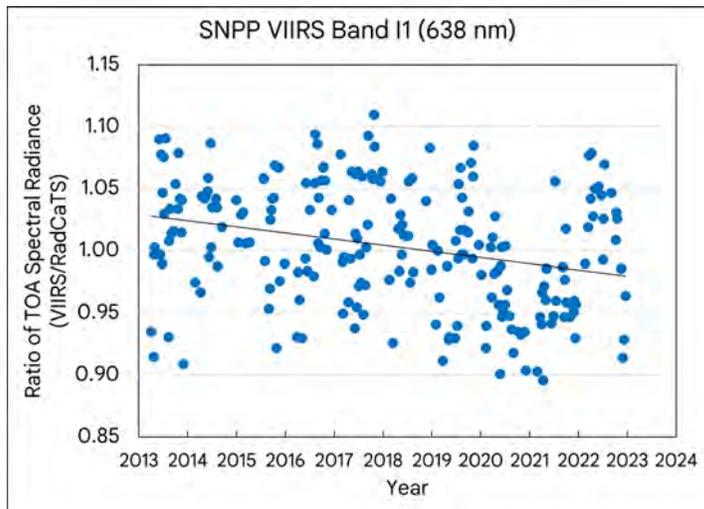
- VIIRS bands: I1–I3, M1–M5, M7, M8, M10, M11
- Double ratio: $(\text{SNPP}/\text{RadCaTS}) / (\text{N20}/\text{RadCaTS}) = \text{SNPP}/\text{N20}$



Temporal Radiometric Calibration Results

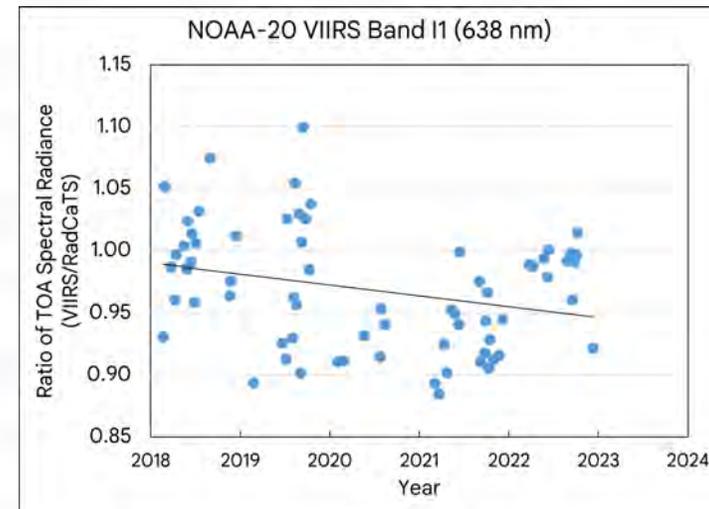


SNPP VIIRS

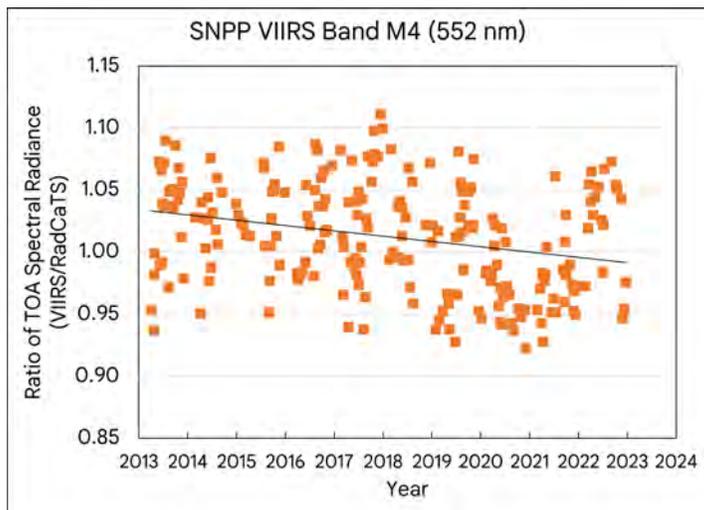


Band I1 (638 nm)

NOAA-20 VIIRS

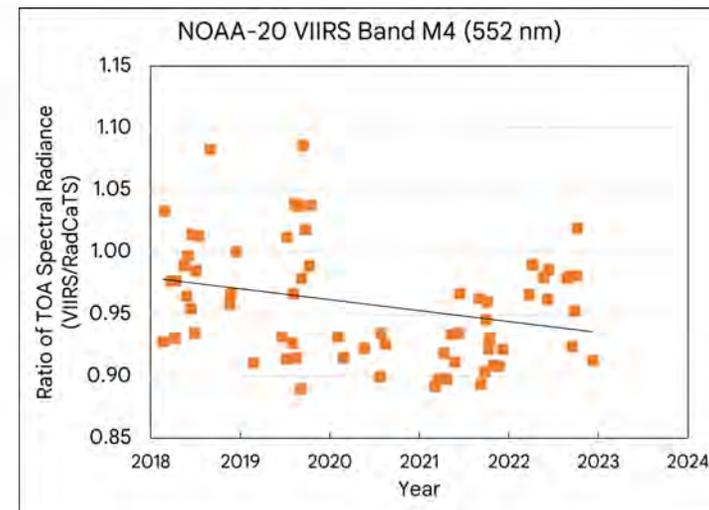


SNPP VIIRS Band M4 (552 nm)



Band M4 (552 nm)

NOAA-20 VIIRS Band M4 (552 nm)

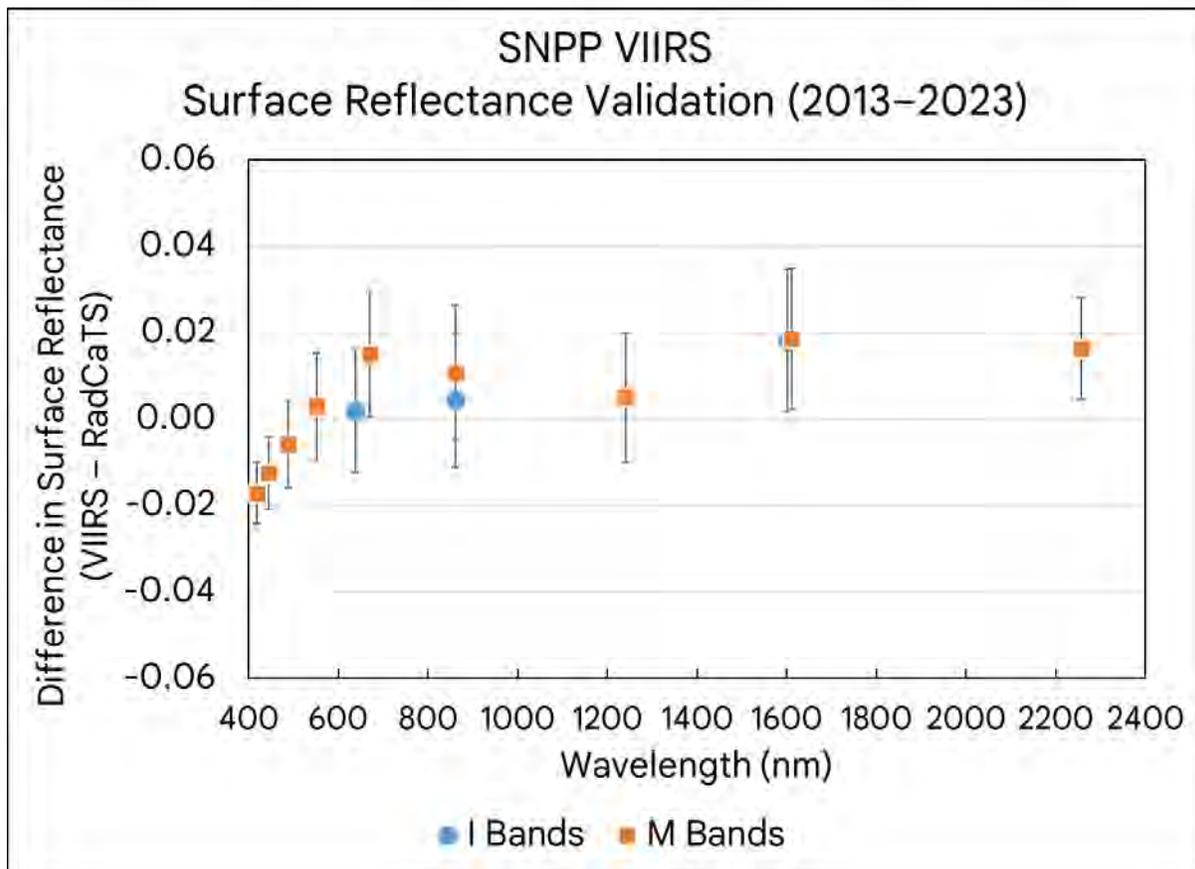




SNPP VIIRS Surface Reflectance Validation Results



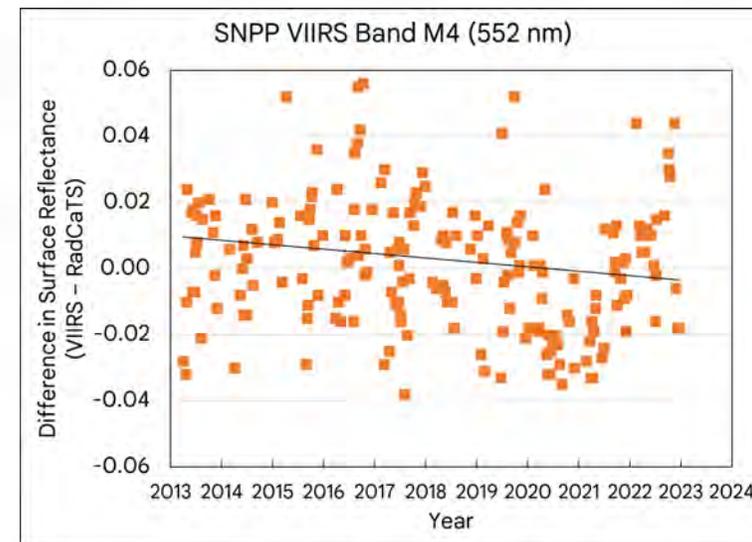
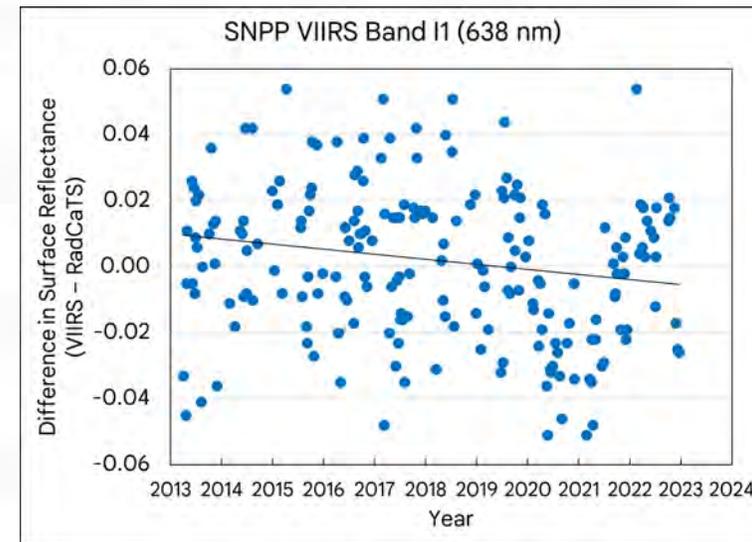
- 2013–2023
- N=225



Band I1 (638 nm)

Band M4 (552 nm)

Temporal Examples

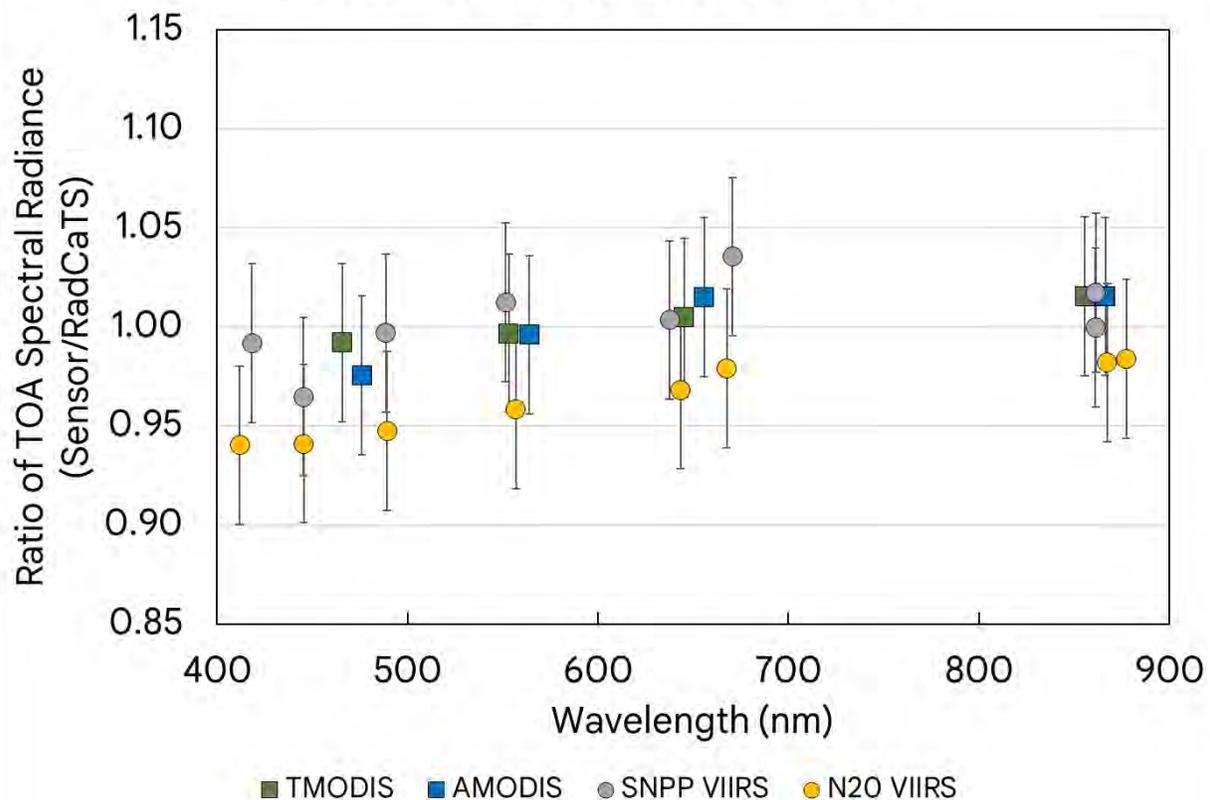


- Summary of all radiometric calibration results

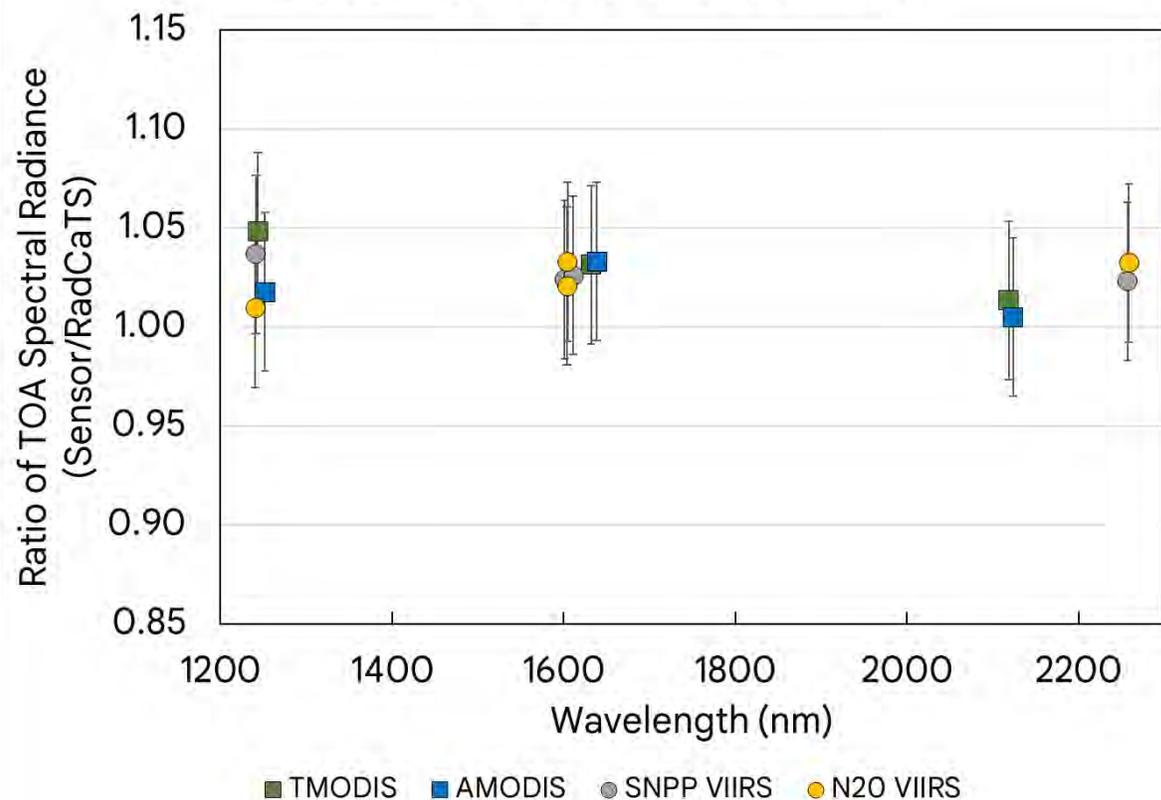
VNIR

SWIR

Radiometric Validation Summary



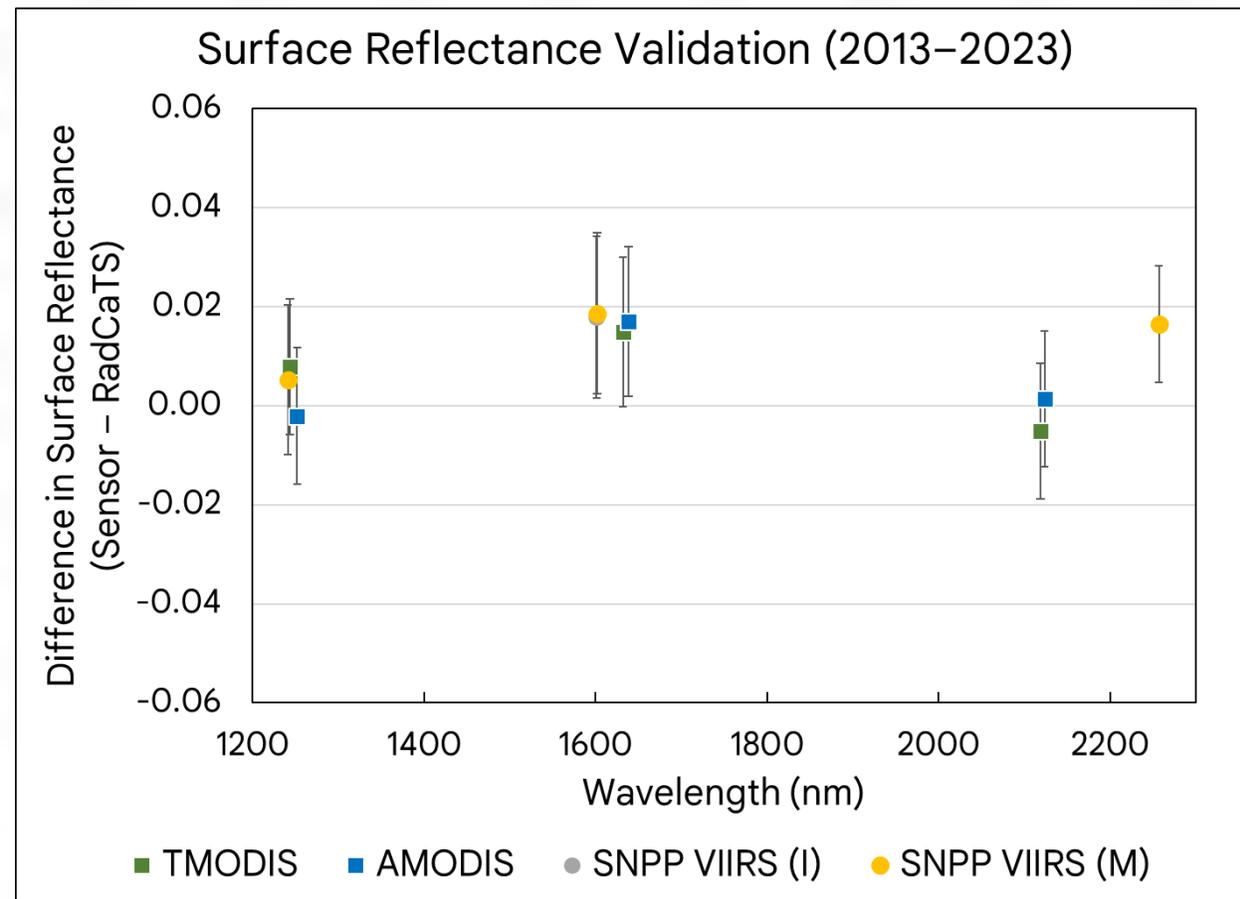
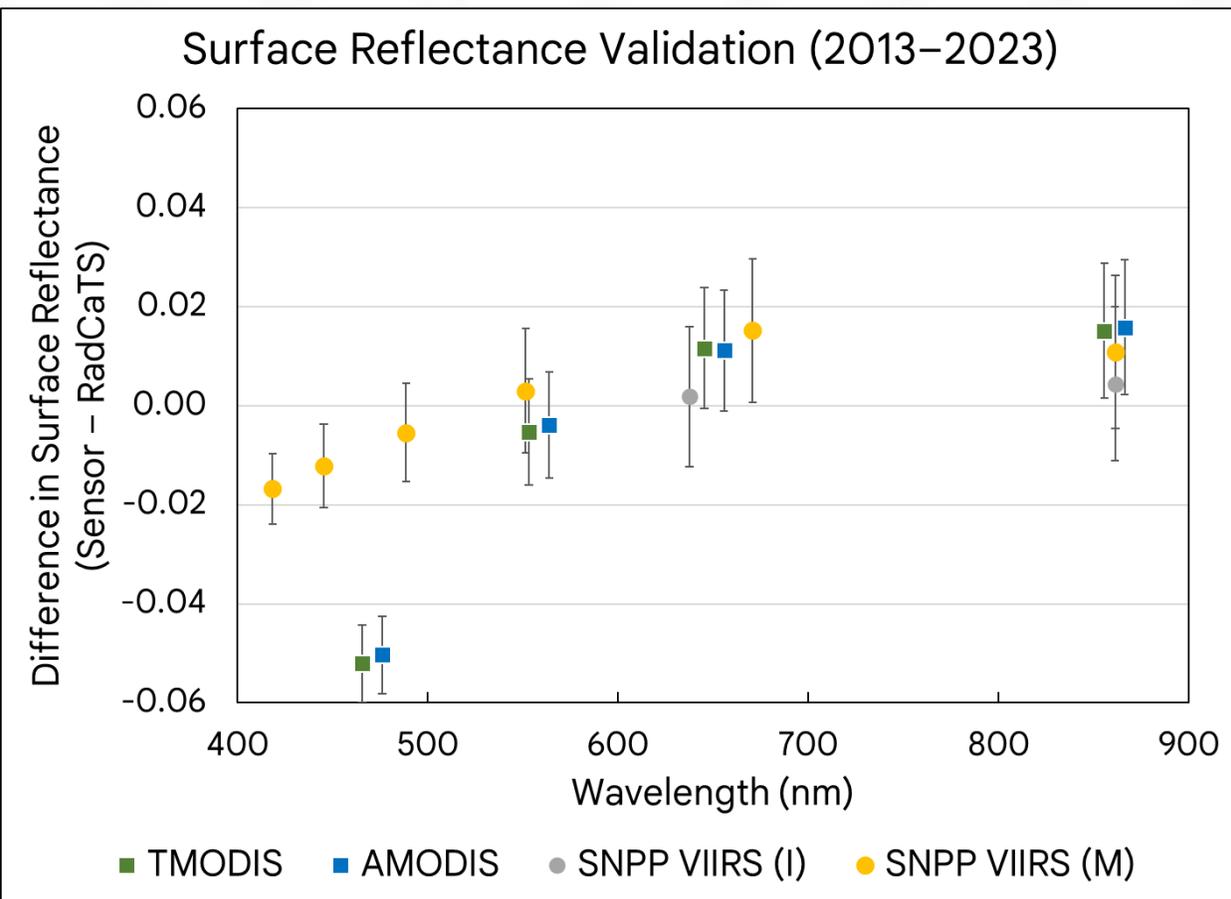
Radiometric Validation Summary



- Summary of all surface reflectance validation results

VNIR

SWIR





- Conclusions

- Terra and Aqua MODIS radiometric calibration agrees with RadCaTS to within uncertainties
- Terra and Aqua MODIS surface reflectance has bias with RadCaTS in blue band
- SNPP and NOAA-20 VIIRS radiometric calibration also agrees with RadCaTS to within uncertainties, except for NOAA-20 Bands M1–M3 (412 nm, 446 nm, and 489 nm)
- Terra and Aqua MODIS are in agreement to within RadCaTS uncertainty when using double ratio (or difference)

- Upcoming work

- Continue the deployment of Headwall UAS for BRDF measurements at Railroad Valley
- On-site calibration of GVRs using CaTSSITTR
- Continued spatial analysis comparison with traditional reflectance-based approach and RadCaTS
- Integrate on-site VNIR spectrometer data into RadCaTS processing



Thanks!



- We would like to thank the Bureau of Land Management (BLM), Tonopah, Nevada office, for assistance and access to Railroad Valley
- We would also like to thank NASA for funding this work, and AERONET for processing the Cimel data



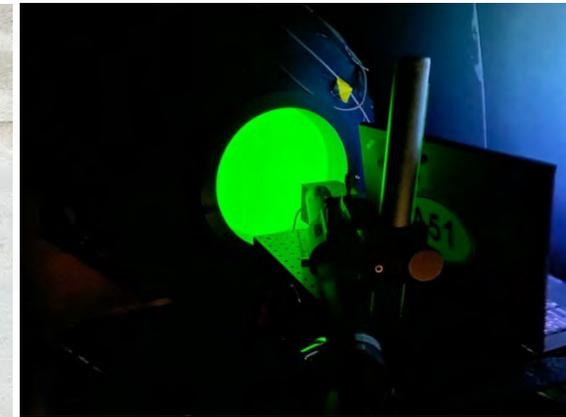
SpAM



Prism based
433 nm to 767 nm



New micro-spectrometer



Grating based
322 nm to 888 nm